SAND2015-1098PE

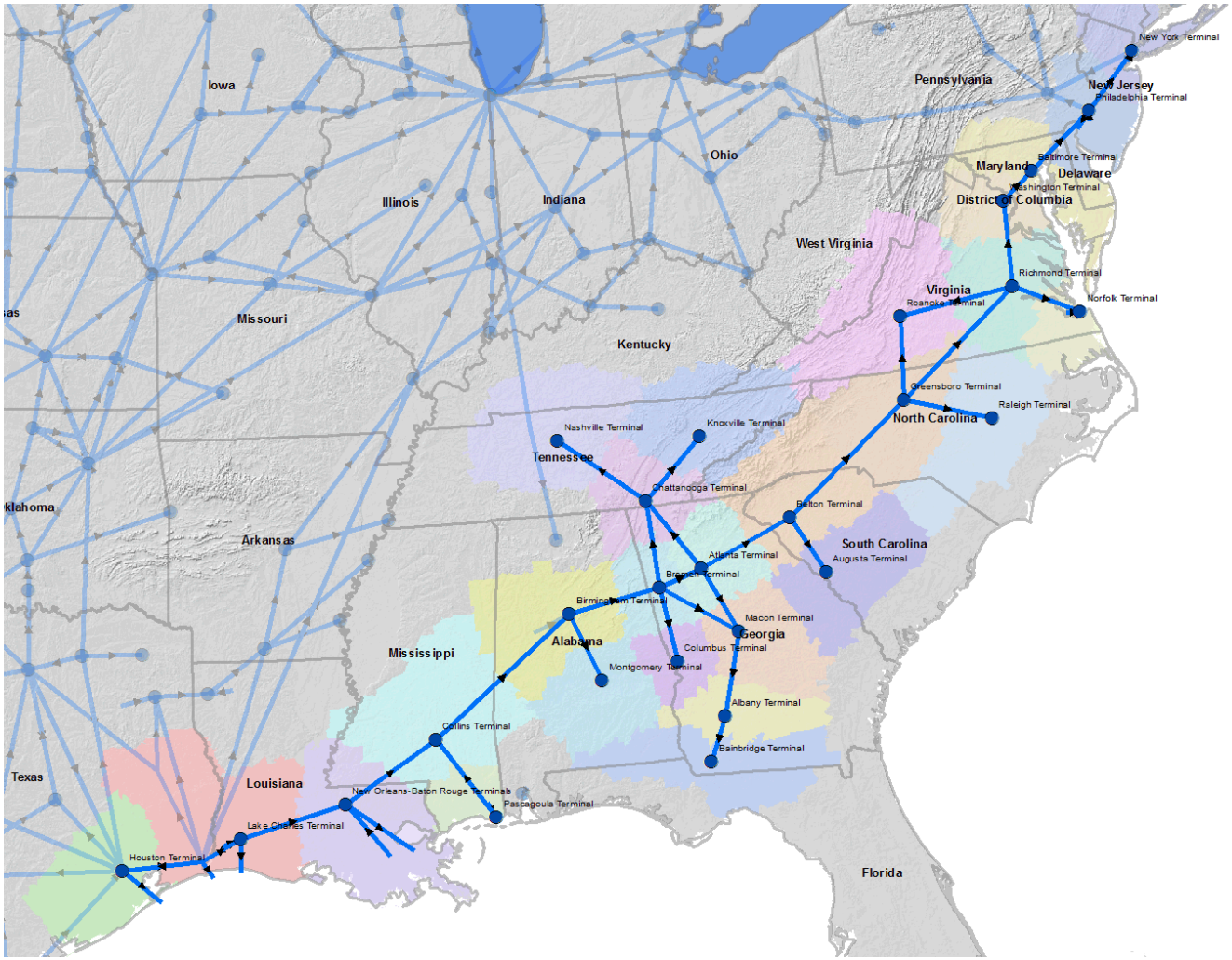
Presentation to Public Safety Canada

At Sandia National Laboratories

February 23, 2015

Homeland Security

Network Modeling Approach



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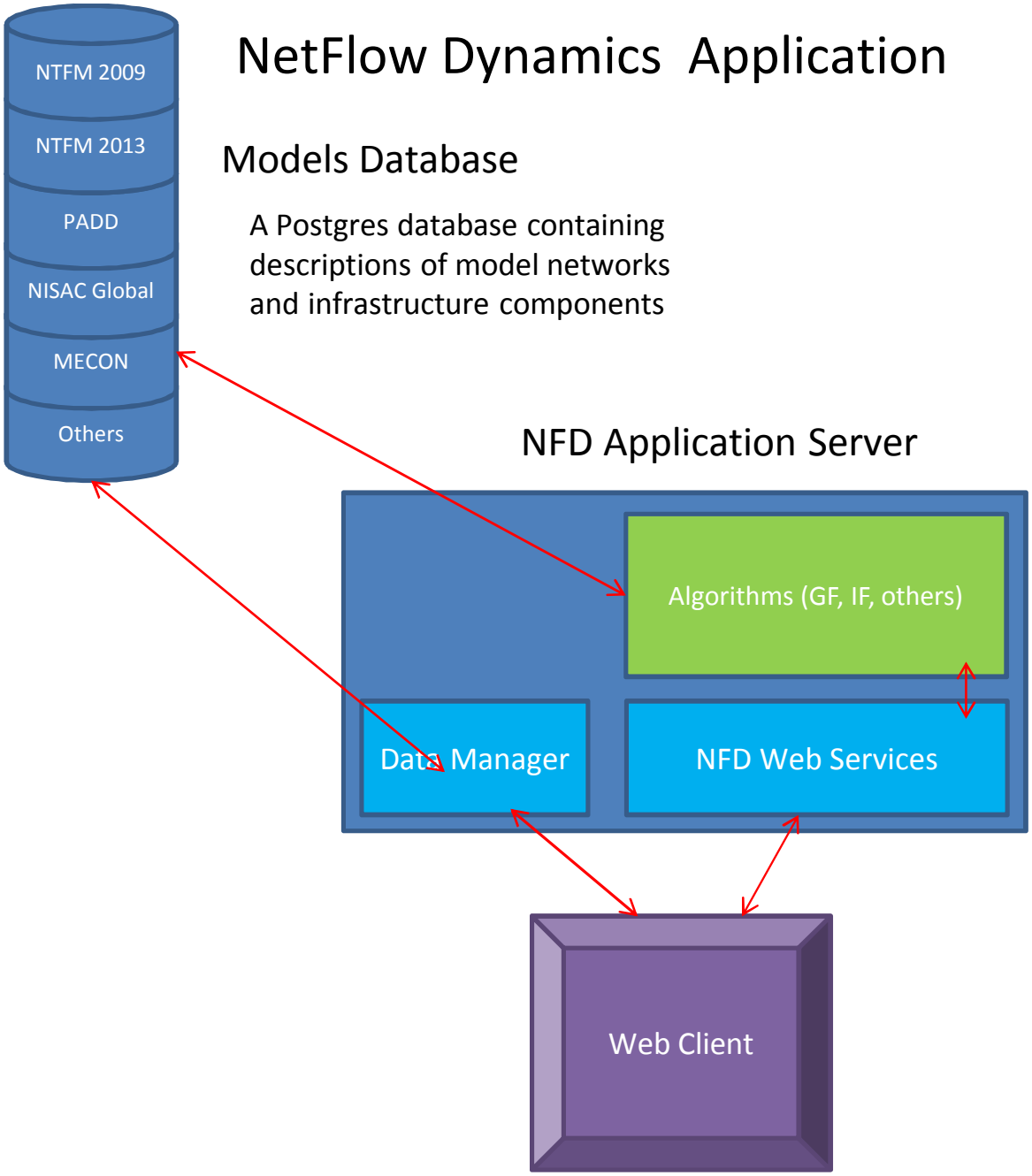
Development and Use Trends

- U.S. fuels model → multiple regions, infrastructures (global, NG?, EP?)
- desktop application → cloud-hosted, web-based application
- basic user interface → GIS-based, flexible user interface
- manual model updates (SNL) → faster and more collaborative updates (SNL, EIA, DOE, other labs?)
- single crude and fuel types → multiple crude and fuel types
- single flow algorithm → multiple flow algorithms
- single analyst group (SNL) → multiple analyst groups (SNL, DHS, DOE, EIA?, others labs?)
- DHS funding → shared funding (DHS, DOE, SNL PD, SNL LDRD)

NetFlow Dynamics Application

Models Database

A Postgres database containing descriptions of model networks and infrastructure components



Network Model Description

- Market-driven Resilience Attributes minimize fuel shortages
  - Re-routing shipments
  - Drawdown of inventory
  - Use of surge capacity
  - Increasing imports
  - Reducing consumption
- Constrained by connectivity of the system and capacity of individual system components:
  - Pipeline flow
  - Refinery throughput
  - Tank Farm storage
  - Import terminal throughput

Some Model Assumptions and Limitations

Includes transmission system (pipelines, rail, water), but not distribution (trucks)

- For example, the model does not know that fuel can't be delivered because roads are damaged

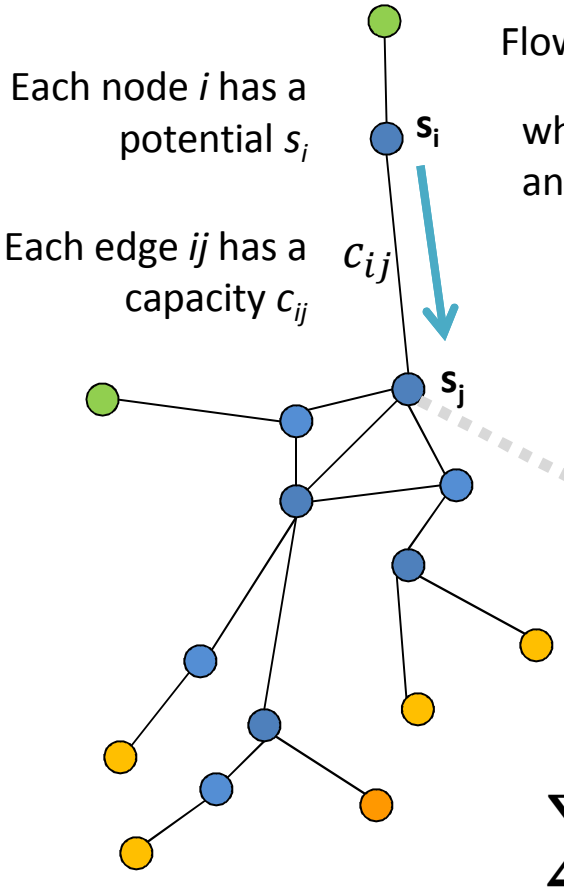
Market behavior is based on fuel availability

- No hoarding behavior (by consumers or suppliers)
- No price increases until inventories decline

Desired consumption of fuel not decreased by damage to other infrastructures (unless decrease specified by scenario)

Minimize shortages while balancing mass and not exceeding capacities

Define & Apply System Models



Flow rates are given by :

$$q_{ij} = c_{ij}\, f\big((s_i - s_j)u_{ij}\big) \quad (1)$$

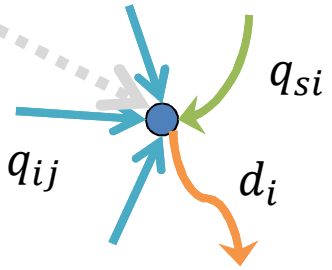
where u_{ij} is a utilization parameter and the function f(x) is:

$$f(x) \equiv 1 - e^{-x} \quad (2)$$

In equilibrium, the net flow at each node *i* is 0:

$$\sum_j q_{ji} + q_{si} - d_i = 0 \qquad \forall i \quad (3)$$

The equilibrium solution $\{\hat{s}_i\}$ is obtained by solving equations (1-3)



In the transient case, net inflow into a node results in the accumulation of stored fluid:

$$\sum_j q_{ji} + q_{si} - d_i = \frac{dv_i}{dt} = r_i \left[1 + \left(\frac{s_i - a_i}{b_i}\right)^2\right]^{-3/2} \frac{ds_i}{dt} \qquad \forall i$$

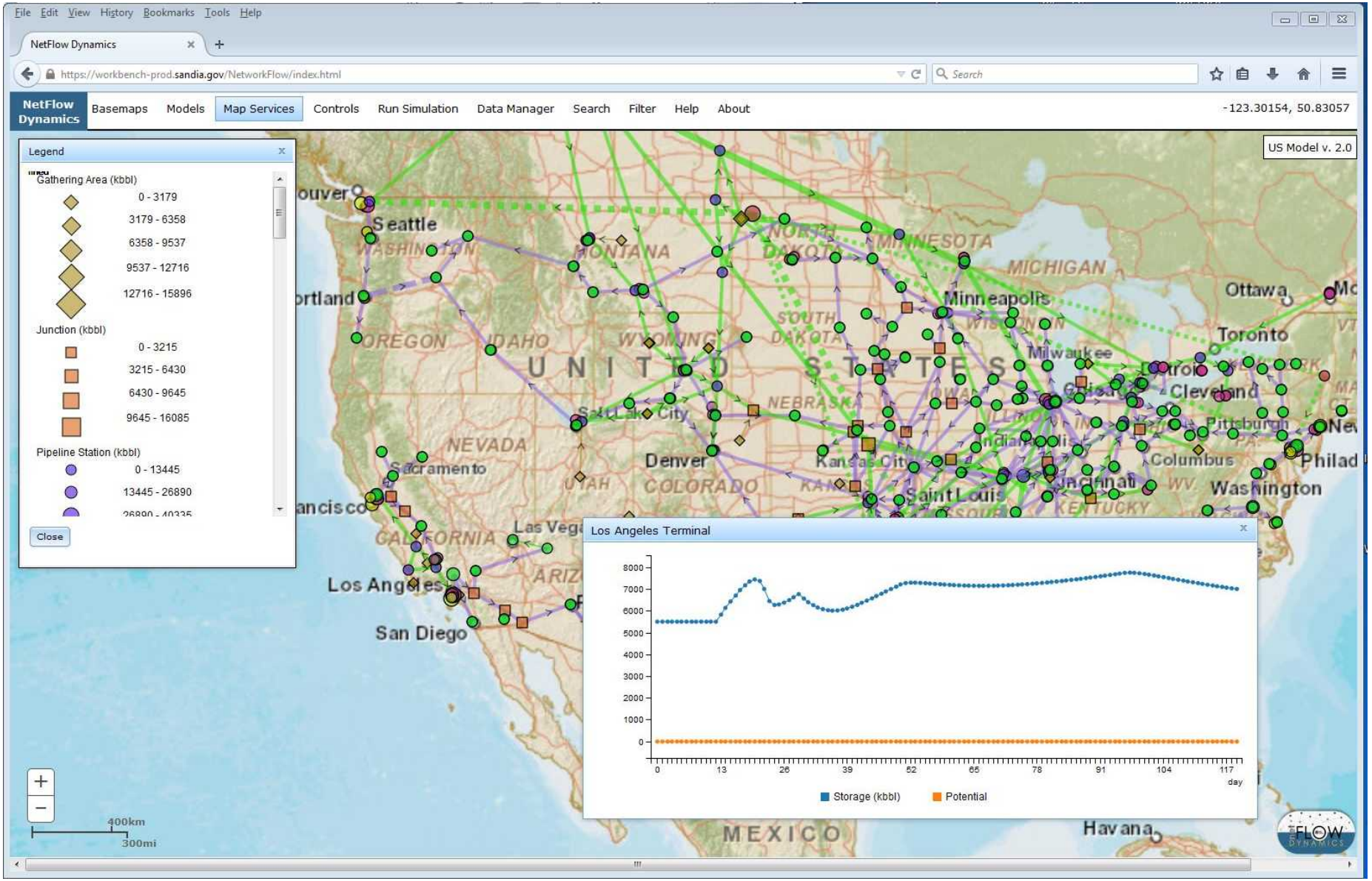
where r_i , a_i and b_i are storage parameters

Beyeler, Corbet, and Hobbs, 2012

Live Model Demonstration

- At this time we will project live simulations being performed by the model
- We will show the model interface showing the simulated impacts of selected disruptions to US or Canadian petroleum facilities.
- The following slide is a screen shot of the model interface showing the type of information that will be presented

Sample screen shot from live demo



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For more information visit:
www.dhs.gov/criticalinfrastructure

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